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NEW NAVY BUOYS DEMONSTRATE GLOBAL REMOTE SAMPLING CAPABILITY

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Abstract

Over the past two years the number of surface and air dropped expendable bathymetric observations received by the Navy has decreased from about 125 to 50 observations per day. Subsequently, the Navy has been investigating new, more economical, techniques for remote sampling of environmental data using satellite-reporting, air deployable, drifting data buoys equipped with a variety of sensors. A buoy that measures air temperature, sea surface temperature and barometric pressure for 90 days has been developed and is now in operational use. Testing of a 100-m thermistor cable on the buoy has demonstrated a 45-day potential. Additional sensors for wind speed, wind direction and broadband ambient noise measurements are being added. Coupled with a new prototype satellite reporting system, a global, near-real-time, oceanographic observing and reporting system is now being demonstrated. This paper describes the Navy's test of such buoys and their application to a global remote sampling capability.

1. Introduction

Sverdrup said in his classic textbook, *The Oceans*, that for observations and collections at sea, "a very sturdy, seaworthy vessel capable of working under practically all weather conditions and of withstanding any storm is required". Throughout history we have sent such vessels to sea to make measurements of the properties of the ocean. The present World Ocean Circulation Experiments (WOCE) will require dedicated research platforms from many nations. However, the cost of this approach increases more each day. With the advent of spaceborne sensors and satellite reporting buoys used for oceanographic data collection, the Navy is seeking alternative means to accomplish a new sampling strategy on a global scale. This paper will present some of the Navy's recent work with satellite reporting drifting buoys used for oceanographic data collection and their application to a global remote sampling strategy.

2. Sampling Strategy-Historical

Of prime interest to the Navy is the collection of temperature and salinity measurements as related to the antisubmarine warfare (ASW) mission area. In our sampling strategy we have progressed from measurements using the bucket thermometer, sea water injection temperatures, Nansen bottles and reversing thermometers, the towed bathythermograph (BT), towed thermistor chains, expendable ship and air launched bathythermographs (XBTs/AXBTs), to remote sensing via spaceborne or airborne radiation based measurements of sea surface temperature. Although we have progressed in our sampling and measurement capability, unfortunately there has been little change in our global ocean reporting strategy.

Presently, XBTs and AXBTs provide the majority of oceanographic thermal structure data. Figure 1 illustrates the decreasing

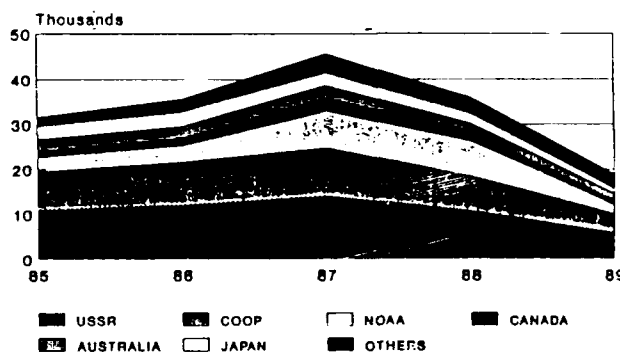


Figure 1. XBTs received at FNOC. (Courtesy of Naval Oceanography Command NEWS article, "Resource Cuts Prompt Evaluation of COOP Program, by Cathy L. Willis, Jan 90).

number of XBTs being received at the Navy's Fleet Numerical Oceanography Center (FNOC). Only about 50 observations are received daily (down from a 1987 high of about 125 per day). One of the major contributors to this data base is the Navy/National Oceanic and Atmospheric Administration (NOAA) sponsored Cooperative Oceanographic Observation Program (COOP) which funds approximately 82 foreign and U.S. commercial ships to collect ocean thermal structure information in data sparse areas of the world. The COOP program provides 18% of the real time bathythermograph observations at FNOC and 50 percent of the bathythermograph information exchanged in the Integrated Global Ocean Services System via the Global Telecommunications System (GTS) and Automated Weather Network (AWN). Unfortunately funding for this program is in jeopardy.

Similarly, Navy Fleet procurement projections for AXBTs will drop in FY91 from approximately 14,000 buoys to a FY94 low of about 2,700 AXBTs to be distributed Fleet-wide. If the COOP program goes, one quarter of the world's unclassified bathymetric information goes with it. With the projected U.S. economic situation, we cannot easily afford to keep ships at sea nor spend money on ever more costly expendable instruments capable of measuring only a single data point. One might ask, what is the Navy going to do?

3. Sampling Strategy-Future

In 1987 the Navy began testing a commercially available, sonobuoy sized, satellite reporting, drifting data buoy. This buoy has a 90-day life, and provides measurements of atmospheric pressure, air temperature, sea surface temperature, and ocean current drift (see Figure 2). This buoy represents the first of three classes of sonobuoy sized data acquisition buoys required by the Navy. It was certified for use in June 1989 and declared operational this year. These buoys have been used to "tag" specific ocean features such as

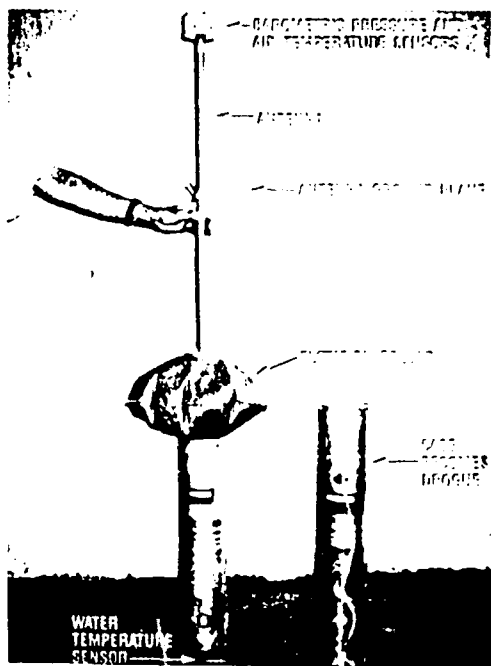


Figure 2. Mini drifting data buoy (photo courtesy of Dr. Robert Pickett, NOARL).

fronts and eddies and acquire other data for meteorological and oceanographic forecasting purposes.

A second version of the mini-drifting data buoy is scheduled for operational testing in late 1990 through 1991. This buoy will have the added capability to acquire subsurface ocean thermal profiles to 300 m, measure wind speed and direction, and sample broad band ambient noise in addition to the capability of the presently configured buoy. As a precursor to this version, a prototype, 100-m, thin line, thermistor cable was added to the meteorological buoy. Testing began during the summer 1989 and is continuing this fall as a technology feasibility demonstration. Already a 45-day potential has been demonstrated and work is in progress to extend that life to 90 days. Several hundred of these drifting buoys have been used in both operational and research scenarios. Data from these buoys are used by the Naval Oceanographic Office (NAVOCEANO) to initialize and maintain dynamic ocean models such as the Navy Operational Gulf Stream Forecast model. Drifting buoys were used in the Persian Gulf mine hunting efforts, for monitoring storms in Project E.R.I.C.A., and to "tag" oil spills and Gulf Stream features. The thermistor cable buoys have been used to study ocean frontal features in the Gulf of Mexico in an effort sponsored by the National Marine Fisheries Service, nine oil companies, and Florida State University (see Figure 3). Figure 4 is data from one of the Gulf of Mexico buoys illustrating the sea surface temperature change as it entered the warmer gulf waters along the loop current/frontal feature. Figure 5 illustrates a buoy track in a warm eddy type feature southeast of Crete. The buoy was trapped in the eddy for over two months.

4. Data Flow-Present

The data flow from these buoys is shown in Figure 6. Data are downlinked from the NOAA TIROS polar orbiting satellites via Service Argos receive sites. The processed meteorological data with buoy positions are sent to: (1) the National Weather Service (NWS)/National Meteorological Center (NMC) for quality control, and

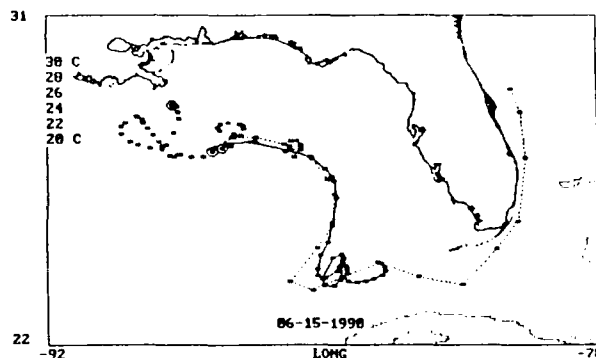


Figure 3. Drifting buoy tracks of three buoys in the Gulf of Mexico from 6 May to 14 Jun 90. (Unpublished data from Dr. Robert Pickett, NOARL).

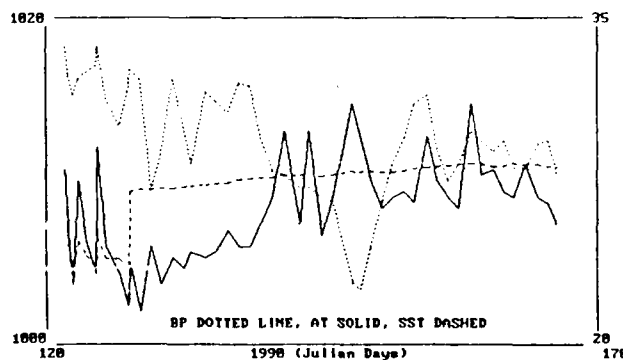


Figure 4. Barometric pressure (dotted line), air temperature (solid line), and sea surface temperature (dashed line) data plot from drifting buoy I.D. 11498 located in the Gulf of Mexico, March-May 90. (Unpublished data from Dr. Robert Pickett, NOARL).

(2) directly to NAVOCEANO. The NWS can send the data to military and/or civilian users by use of the Awn and GTS circuits. The Awn/GTS bulletins are in standard World Meteorological Organization (WMO) code in DRIBU or SSXV KARS format.

During one test in the Gulf of Mexico, eight buoys with thermistor cables were daily transmitting up to 70 near-real-time bathy observations to the NMC (worldwide average is only a total of 50 per day). With automated editing and processing routines in place, the amount of ocean thermal data available for ocean modeling and analysis can be greatly increased. Presently, archiving of the drifting buoy data is done only at NAVOCEANO. The Commander Naval Oceanography Command (COMNAVOCEANCOM) has also set up a Local User (downlink) Terminal (LUT) network to provide a near-real-time coverage over the entire Atlantic, Arctic, and north Pacific Oceans. The buoy data are received directly into these downlink terminals and can be manually input into the Awn.

NAVOCEANO has plans to routinely deploy several hundred sonobuoy-sized drifting buoys from fleet aircraft on an annual basis. To process drifting buoy and other remote sensed oceanographic data on a daily basis, the Operational Oceanography Center (OOC) has been established at the NAVOCEANO. Additionally, by the mid 1990s, local receive and processing capability will be included in the next generation Tactical Environmental Support System (TESS 3.0), a system deployed on most Naval Oceanography Command units

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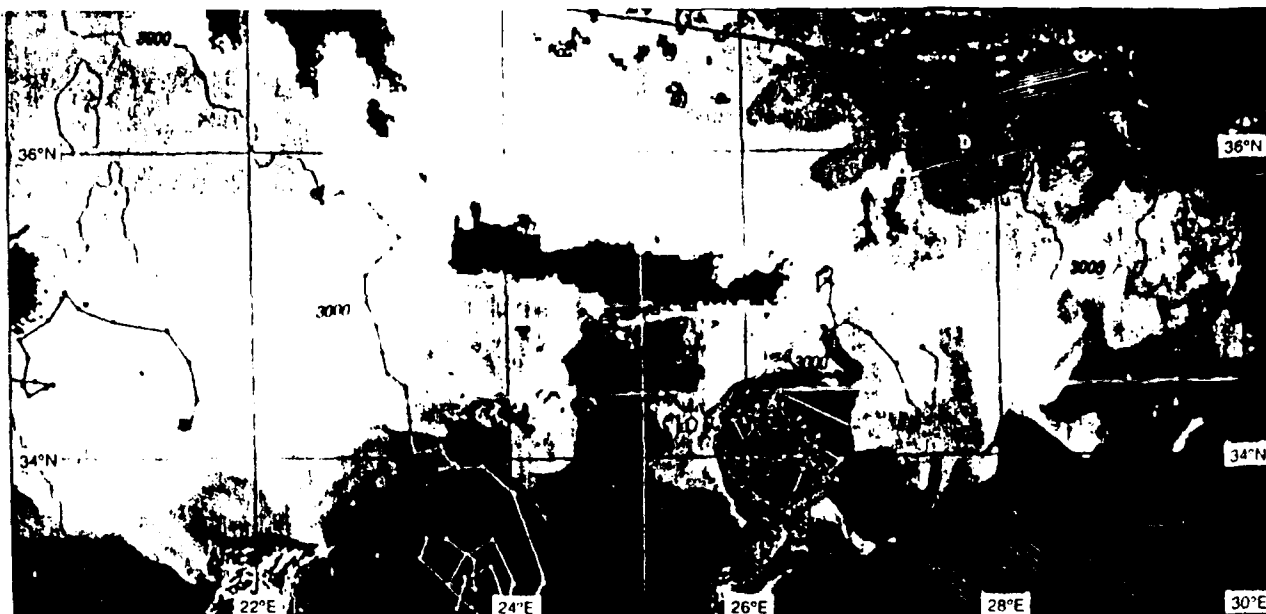


Figure 5. Mini drifting data buoy (with 100 m thermistor cable) track in warm eddy feature southeast of Crete, March-April 90. (Satellite photo by NOARL Code 321).

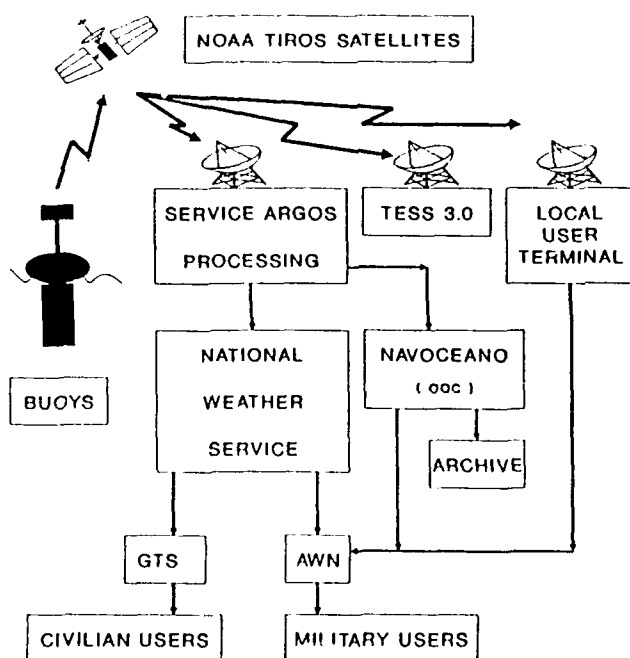


Figure 6. Drifting buoy data flow.

afloat and at major ASW support shore establishments, thus greatly expanding the Navy user base of drifting buoy data.

5. Data Flow-Future

The Naval Space Command, as the Navy/Marine Corps demonstration agent, will coordinate with Defense Advanced Research Projects Agency's (DARPA) Applied Satellite Technology

Office (ASTO) on a series of demonstration projects using experimental communications relay satellites. COMNAVOCEANCOM has proposed to use these satellites in a demonstration mode to relay oceanographic/environmental data fields and drifting buoy data directly to ships at sea and selected ground stations. The satellites are called Multiple Access Communications Satellites (MACSAT and MICROSAT). Two MACSATs were launched on a SCOUT rocket earlier this year. Seven MICROSATs will be launched later this year on a PEGASUS Air Launch Vehicle (ALV). These launch vehicles are relatively cheap (\$6M) but have a limited payload capability (400 lbs). They can launch up to seven MICROSATs per carriage. Conceivably, a constellation of seven satellites per plane with three orbital planes could provide a continuous world-wide coverage. Such a communications relay capability coupled with continuously sampling expendable mini drifting data buoys would add a near-real-time global oceanographic observation and reporting structure that could potentially provide an enormous amount of data to the oceanographic community.

6. Economic Advantage

Ships cost tens of thousands of dollars a day to keep at sea and planes cost over a thousand dollars an hour. A reporting and ocean observation system as proposed would also be more economical than ship or aircraft type surveys dropping expendable profilers that give limited amounts of data per survey. For example, the existing Air Sea Interaction (ASID) buoys in use by the Navy are over 3.3 m (11 feet) long and weigh over 4 kN (900 lbs). They have about a one year life and cost \$25K-\$35K each excluding the cost of the logistics to deploy them. In contrast, mini drifting data buoys with equal measurement capabilities but shorter life expectancies are estimated to cost \$3.5K per buoy (including processing costs), yielding savings of 50-60% for one year of operations. If produced in an assembly line operation like sonobuoys these costs could be significantly reduced. These buoys report every 90 seconds and update and sample the data hourly. An expendable BT (XBT/AXBT) costs

about \$34 to \$140 respectively and provides a single profile. A sonobuoy sized drifting data buoy with a 300-m thermistor cable could provide meteorological, oceanographic, and acoustic data hourly and provide anywhere from 700-2000 observations over a three month span depending on available satellite coverage. The data can be relayed via satellite in near-real-time and be available over a global area depending on the density of buoy coverage available.

7. Conclusions

In summary, I have attempted to outline a new Naval Oceanographic strategy to bring oceanographic observing and reporting to a remotely sampled, oceanwide and perhaps global as well as a regional and local scale. Research is underway to develop more multi-sensor, satellite-reporting, expendable buoys with the goal of not only meeting Navy requirements but national and international needs as well. Cheaper, multi-parameter measurement expendables are needed. They offer potential as highly specialized survey tools

to enhance our data base and should be routinely deployed in cooperative programs such as the COOP effort. The results can be made available in near-real-time to the oceanographic user community. They are the "seaworthy vessel" of the future.

Acknowledgments

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